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DEPARTMENT OF THE ARMY
Fort Detrick
Frederick, Maryland

FORMING THE IMAGE OF THE SURFACE OF MEMBRANE FILTERS IN THE ELECTRON MICROSCOPE: A CONTRIBUTION
[See Note]

H. J. Preussen, Institute for Aerobiology (Director: K. Bisa, M. D.)

[Note]: An extract from work performed at the instigation of the Membranfiltergesellschaft GmbH (Membrane Filter Company Inc.), Göttingen.

Membrane filters are partially permeable layers made of cellulose esters which are employed to separate coarsely dispersed and colloidal particle sizes from substances. The framework substance of the filters constitutes a multilayer high-porosity system of spherical cavities. The pore size of the filters and hence their filtering effectiveness can be altered by differences in fabrication. It has been possible to improve the fabrication of membrane filters to such an extent that today filters with an average pore diameter between 0.1 and 5 μ in more than ten graduated sizes are on the market. Thus they can be employed for investigations ranging from phage filtration to dust precipitations to aerosol filtration. The electron microscope is necessary in many cases in order to make visible the particles separated by the filter. Since the membrane filter by reason of its film thickness ranging from 50 to 200 μ is impermeable to electrons, preparation problems result, and it is to the solution of these that we should like to contribute here.

The structure of the surface deviates significantly from that of the inside of the filter. By the manner of fabrication a surface membrane interspersed with pores is formed, while the inside consists of a system of spherical

cavities interspersed with ridges (Helmcke, 1954). Let us designate as the "air side" the surface membrane produced during the manufacture of filters to be the boundary layer between the fluid filter mass and the air. On the other hand, let us designate as the "plate side" the terminal layer (Abschlussschicht) produced in the event of effusion between the plate and the fluid filter mass and thus representing the bottom of the filter.

In order to form an electron-microscopic image of the fine structure of the air and plate side as well as the internal structure, membrane filters of the MF 15 type [See Note] were vertically vapor-coated with carbon in a vaporizer. Prior slanting vapor-coating to heighten contrast was found to be unnecessary. The filter substance was immediately afterwards dissolved with an organic solvent either completely or all except a thin residue layer. The carbon film (with or without the adhering filter residue layer) reproducing the surface structure was caught on carrier nets and examined in the ELMISKOP I electron microscope at primary magnification 5000 and 10,000 X. If the filter substance is only incompletely dissolved, one can discern in the electron microscope the system of spherical cavities interspersed with numerous ridges (Figure 1), as described by Helmcke (1954). On complete removal of the filter residue from the vaporization layer an image not only of the air-side but also of the plate-side filter surface with its pores can be produced electron-microscopically (Figures 2 and 3). The number, diameter and area of pores on both filter surfaces can be determined with a ZEISS particle-size analyser. For the membrane filter type examined here, the following values were obtained which were ascertained from about 7000 individual measurements on 36 images of a number of filters:

	Air side	Plate side
Number of pores per sq cm of filter surface	6.41×10^7	8.35×10^7
Average pore diameter	270 mμ	287 mμ
Proportion of pores on filter surface	5.79%	7.05%

[Note]: MF 15 membrane filter in weight-constant production without plasticizers of the Membranfiltergesellschaft GmbH (Membrane Filter Company Inc.), Göttingen.

These measurement results lead us to the following reflection: If we filter with the so-called plate side up, a portion of the precipitation will be retained, not on the

filter surface but inside the filter by reason of the smaller number of pores and the smaller pore diameter of the air side, and this portion cannot be included during light-microscopic or electron-microscopic investigations of surfaces. These substances will in part accumulate in front of the exit from the filter in the immediate vicinity of the bottom terminal membrane (Abschlussmembrane) and may possibly impair filtering efficiency.

BIBLIOGRAPHY

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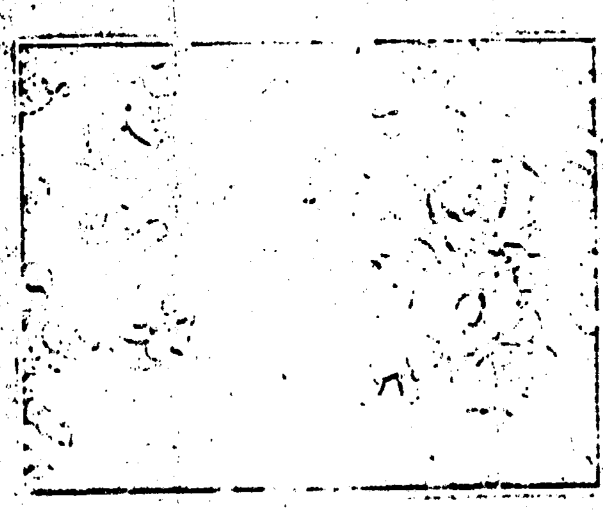

Figure 1. Internal structure of an MF 15 membrane filter. A system of spherical cavities divided by ridges and little beams.

V_e [Eigenvergrösserung; primary magnification] = 10,000 X.

V_g [V, Vergrösserung, magnification; g, unknown] = 25,000 X.

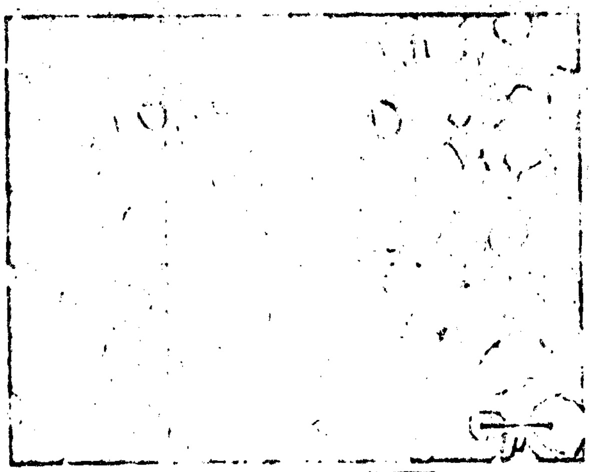

Figure 2. Plate-side filter surface of an MF 15 membrane filter with numerous pores

V_e [Eigenvergrösserung; primary magnification] = 5000 X.
V_g [V, Vergrösserung, magnification; g, unknown] = 10,000 X.

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Figure 3. Air-side filter surface of an MF 15 membrane filter with numerous pores.

V_e [Eigenvergrösserung; primary magnification] = 5000 X.
V_g [V, Vergrösserung, magnification; g, unknown] = 10,000 X.